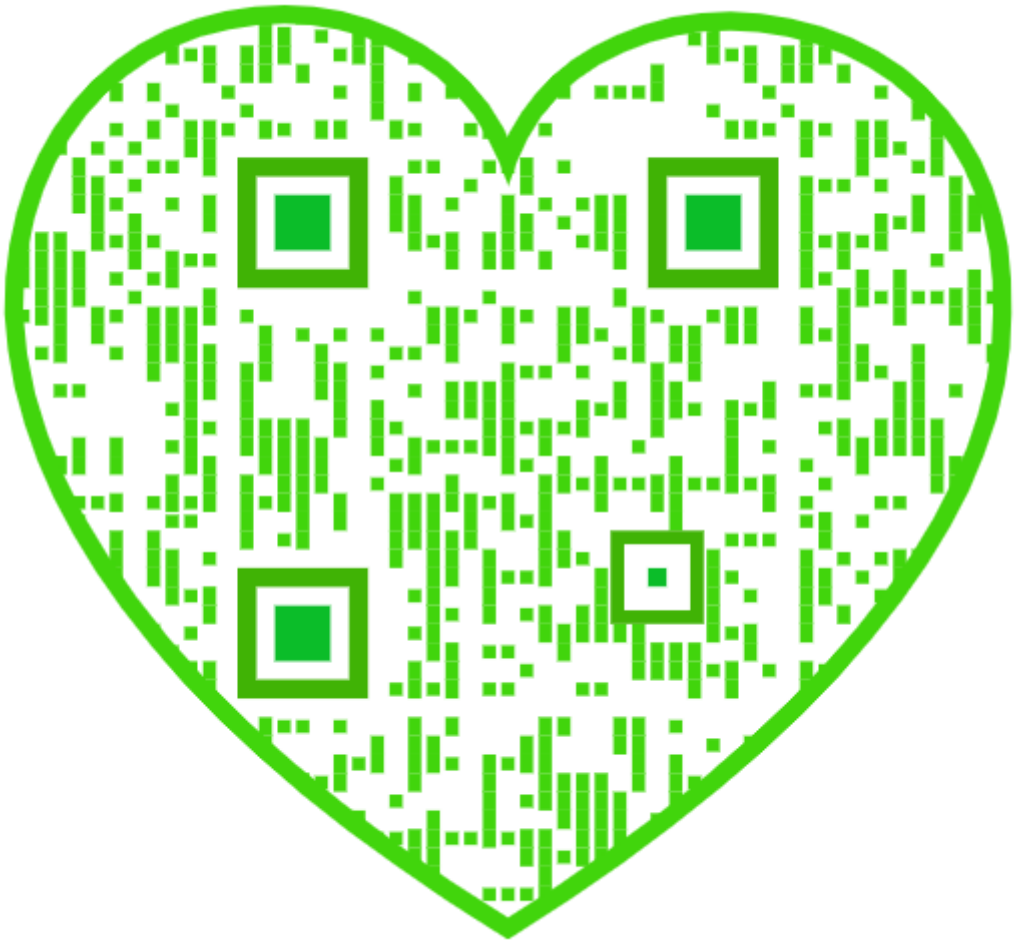

PUBLICATION 505 ISSUED APRIL, 1936
REPRINT FROM FARMERS' BULLETIN 3

DOMINION OF CANADA—DEPARTMENT OF AGRICULTURE

INSECTS ATTACKING THE POTATO

By

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Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada
Canadian Agriculture Library
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ENTOMOLOGICAL BRANCH

630.4
C212
P 505
1936
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Published by authority of the Hon. JAMES G. GARDINER, Minister of Agriculture
Ottawa, Canada

INSECTS ATTACKING THE POTATO

BY

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One of our most commonly cultivated field and garden crops, the potato, is frequently attacked by insects of one species or another. Although the foliage is most frequently injured, damage to the stems and tubers is not at all uncommon. Fortunately, most of the insects attacking the leaves and stems of the plants can be easily controlled if remedial measures are taken early. But, as is true in the case of all injurious forms, the best results can be expected only if insecticides are applied as soon as the insects appear.

In planning control operations it should be borne in mind that insects, according to the manner in which they feed, may be divided roughly into two classes, namely, biting or chewing insects, and sucking insects. The former, in feeding, actually chew pieces out of the leaves and can, therefore, be killed by coating the surface of the foliage with a stomach poison such as arsenate of lead. The latter class, on the other hand, suck the juices from the plant by means of a sucking tube inserted into the tissues. They must be fought by a contact poison, as, for instance, nicotine sulphate, which kills the insects when it comes into contact with their bodies. Stomach poisons have no controlling effect on sucking insects.

To assist the grower in identifying the insects attacking his potato vines, the following key has been prepared. A key to insects commonly found feeding on the tubers precedes the chapter dealing with those species.

IDENTIFICATION KEY TO INSECTS ATTACKING POTATO FOLIAGE

I. Large insects, at least $\frac{1}{4}$ of an inch in length:

(*a*) Insects with hard bodies, having the wing covers marked with cream and black stripes.

Colorado Potato Beetle

(*b*) Insects with comparatively hard bodies, uniformly grey, purplish or black.

Blister Beetles

(*c*) Insects with softer bodies, greenish-yellow with four black stripes on the thorax and outer wings.

Four-lined Plant Bug

(*d*) Grubs with very soft bodies, brick-red, with black markings, quite small when young.

Colorado Potato Beetle Larvæ

II. Small insects, much less than $\frac{1}{4}$ of an inch in length:

(*a*) Dark blue to black, jumping actively when disturbed.

Potato Flea Beetle

(*b*) Pale green, active, more or less solitary.

Potato Leafhopper

(*c*) Pale to dark green, moving very slowly when disturbed, feeding in clusters.

Potato Aphids

Reprint from Farmers' Bulletin 3, "The Potato in Canada", by T. F. Ritchie, Division of Horticulture, Dominion Experimental Farms.

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INSECTS ATTACKING THE FOLIAGE

The Colorado Potato Beetle*

The Colorado potato beetle is sufficiently well known to most growers to need little introduction. The adult is a hard-shelled beetle, about $\frac{3}{8}$ of an inch in length, having the wing covers ornamented with yellow and black stripes. It winters in the soil, and in the spring, often before the new crop of potato plants is up, may be seen wandering over the soil waiting for its favourite food plant to appear. The eggs are laid on the undersides of the potato leaves, and the young, as soon as they hatch, attack the foliage; both adults and larvæ are destructive, but the latter do more damage than the beetles. Tomato, egg plant, tobacco, and nightshade are also attacked. The Colorado potato beetle is found in every province of the Dominion.

Fig. 1.—The Colorado potato beetle; hair line indicates natural size (after Gibson).

CONTROL

Eastern Canada.—This insect can be easily and satisfactorily controlled by spraying or dusting the vines with an arsenical. Since potatoes are frequently attacked by fungous diseases it is customary to dilute the poisons in Bordeaux mixture rather than water, in this way controlling both insects and diseases in the one operation. Spraying is perhaps the most generally accepted method of applying the insecticide when fighting this insect, although dusting is almost as effective. Control measures should be undertaken as soon as the first eggs hatch; the operation should not be delayed until the plants commence to show signs of injury. Make the first application early and repeat when necessary. Treatments are usually made at intervals of 10 days to 2 weeks, depending on weather conditions and the seriousness of the attack, and 5 or 6 applications during the season are commonly given. Spray or dust thoroughly, covering the upper and lower surfaces of the leaves. If spraying, use 100 to 120 gallons of spray per acre at each application in the case of fully grown plants and proportionately less where full growth has not been attained. At least 50 pounds of dust should be used where dusting is practised.

When spraying, use either 2 pounds of arsenate of lead, $1\frac{1}{2}$ pounds of arsenate of lime or $\frac{3}{4}$ of a pound of Paris green to 40 gallons of 4-4-40 Bordeaux mixture. Directions for making Bordeaux mixture will be found on page 18. If the arsenicals are diluted in water instead of Bordeaux, 2 or 3 pounds of hydrated lime should be added when Paris green is used, since this prevents any possibility of burning.

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* *Leptinotarsa decemlineata* Say.

The best dust to use is one composed of 12 pounds of dehydrated copper sulphate, 8 pounds of arsenate of lime and 80 pounds of hydrated lime. This dust has a fungicidal value as well as being a good insecticide. If fungous diseases are not a factor of importance a dust made up of 8 pounds of arsenate of lime and 92 pounds of hydrated lime will give good results against the potato beetle.

Prairie Provinces.—On the prairies, a dust composed of 1 part of arsenate of lime or Paris green to 10 parts of hydrated lime is recommended. In areas where there is no dew, white arsenic can be substituted for arsenate of lime and used at the same strength. In Alberta, arsenate of zinc has given excellent control when diluted with hydrated lime or flour, at the rate of 1 to 10. Sprays of arsenate of lime or Paris green diluted in water as recommended for Eastern Canada can also be used with good results.

British Columbia.—Spray or dust with any of the arsenicals as advised for Eastern Canada.

The Potato Flea Beetle*

The potato flea beetle, a tiny insect which commonly passes unnoticed, frequently causes severe injury to the foliage of potatoes by eating small round holes through the leaves. In severe cases of infestation the holes become

Fig. 2.—Typical injury to potato foliage by the potato flea beetle (after Gibson).

sufficiently numerous to cause browning and death of the foliage. The beetle itself is only about $\frac{1}{16}$ of an inch in length and is black with brown legs. It is able to jump very actively and, due to this habit, is elusive and difficult to see.

* *Epitrix cucumeris* Harr.

The adults feed readily on a wide range of vegetables and weeds, the larvae living in the soil where they attack the roots. In the case of the potato, the tubers are sometimes attacked, resulting in the formation of small, brownish, corky areas. In some instances these are flat or slightly sunken, in other cases definite depressions or tunnels into the flesh are formed while, less frequently, tiny pimples are produced. The faintly brown, corky tissue is evident, however, under all circumstances. If these areas are cut through, it will be found that usually this corky tissue is projected into the flesh in the form of a fine sliver-like structure.

FIG. 3.—Potato injured by the feeding of potato flea beetle larvæ (original, from photo by R. P. Gorham).

A more definite "pimply" condition is sometimes noticed in which the surface of the potato becomes covered with low, wart-like pimples. This is caused by some other agency which is, as yet, unknown. Quite severe epidemics of this "pimply" condition are noticed in certain years and growers are asked to co-operate with the Department of Agriculture by sending in samples for examination and study.

FIG. 4.—"Pimply potato", caused by some unknown agency (original, from photo by D. J. MacLeod).

CONTROL

EASTERN CANADA.—These insects are easily controlled by spraying the foliage with 4-4-40 Bordeaux mixture as described on page 18. Make the first application as soon as the insects are seen and repeat in 10 to 12 days, or when necessary.

Prairie Provinces.—Treat the plants when the injury first becomes apparent, with a dust composed as follows:—

Paris green	1 part
Copper carbonate	1 part
Hydrated lime	4 parts

Repeat the application as soon as the work of the beetles is again noticed.

British Columbia.—Spraying with Bordeaux mixture alone acts as a deterrent. Paris green or arsenate of lead may be added to the Bordeaux to make it more effective, or these may be used alone; 1 pound of arsenate of lead or ½ pound of Paris green and 4 ounces of casein should be used to each 40 gallons of water. In the latter case, ½ pound of freshly slaked lime should be added. Arsenate of lead (powder) or Paris green may also be used dry and should be mixed with hydrated lime at the rate of 1 pound of the poison to 20 pounds of hydrated lime, and the mixture dusted over the plants in the early morning when the dew is on. In the case of tomato plants, protection may be secured by the same treatment or by dipping the whole plant except the roots, before planting, in a mixture of 1 pound of arsenate of lead in 10 gallons of water.

Blister Beetles

Sometimes referred to as "old fashioned potato-bugs," due to the fact that they were responsible for most of the injury to potato vines prior to the invasion of the Colorado potato beetle, these insects are occasionally found in swarms in potato fields. They have the habit of appearing suddenly and, after feeding for a short time, disappearing with equal abruptness. The injury brought about

Fig. 5.—The black blister beetle; hair line indicates natural size (after Gibson).

by these beetles closely resembles that of the Colorado potato beetle, but unlike that species, only the adults are destructive, the first stage larvæ living in the ground where they feed on grasshopper eggs. The adults are fairly large, about ⅝ of an inch in length, soft-bodied and grey, black or purplish, in colour. They are found in every province of Canada.

CONTROL

EASTERN CANADA.—Dusting or spraying infested plants with an arsenical is recommended when the insects become sufficiently numerous to cause commercial injury. If dusting is preferred, use arsenate of lead or arsenate of lime diluted with hydrated lime at the rate of 1 part to 5 parts of the former or 1 part to 7 parts of the latter. When spraying, use 2 pounds of arsenate of lead or 1½ pounds of arsenate of lime to each 40 gallons of water.

FIG. 6.—Adults and nymphs of the potato leaf hopper (after Dustan).

Sodium fluosilicate is recommended in the United States for the control of blister beetles. This poison is diluted with equal parts of hydrated lime and thoroughly dusted over the plants as soon as their feeding is noticed. It is supposed to act more quickly than arsenicals and to be equally, if not more, effective.

Prairie Provinces.—In Manitoba and Saskatchewan, blister beetles are controlled by dusting the infested plants with arsenate of lime, used at the rate of 1 part of the poison to 10 parts of hydrated lime. In Alberta, spraying the plants with arsenate of lime 1 pound, nicotine sulphate $\frac{3}{8}$ of a pint, soap $2\frac{1}{2}$ pounds to 40 gallons of water is recommended.

British Columbia.—Use remedies as advised for Eastern Canada.

The Potato Leafhopper*

The potato leafhopper is a small, green, very active insect commonly found on the under surfaces of potato leaves. It feeds by sucking the juices out of the foliage, causing it to change in colour from dark to pale green and, in severe infestations, to yellow. Frequently the margin and tips of leaves attacked by these insects turn brown and in cases where the insects are very abundant defoliation takes place. The larvæ resemble the adults in colour and shape but are wingless and, except when fully grown, are considerably smaller in size. Although present in all provinces of Canada the potato leafhopper is a pest of importance only in the east.

CONTROL

Use 4-4-40 Bordeaux as advised for flea beetles on page 18. Spray particularly the under sides of the leaves, making the first application when the leafhoppers commence to attack the plants. Repeated spraying should be given at 10 day intervals as needed.

The Potato Aphid*

This insect is not present in injurious numbers annually, but sudden outbreaks appear at irregular intervals when weather conditions are suitable. The potato aphid is a sucking insect, clustering in immense numbers on the undersides of the leaves and on the young shoots, where it causes a distinct yellowing of the foliage. In severe infestations the leaves turn brown and die. The insect is pale green in colour. It is normally found in clusters or groups and is extremely sluggish, moving slowly even when actually disturbed. In years of abundance it can cause very serious losses and should be watched for carefully.

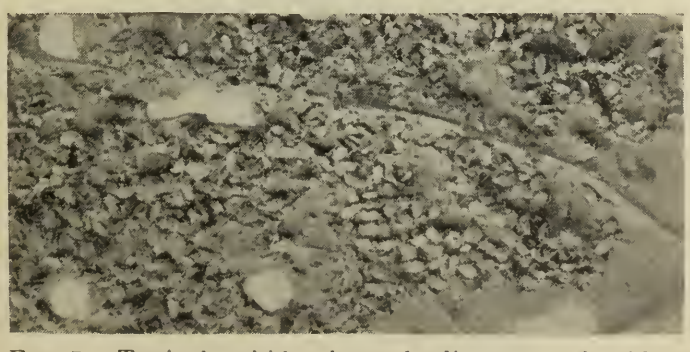

Fig. 7.—Typical aphid colony, feeding on underside of leaf (after Dustan).

CONTROL

Dust the vines with a 2 per cent nicotine dust when the first aphids are seen, using a cotton trailer behind the duster. Directions for the preparation

* *Empoasca fabae* Harr.
* *Illinoia solanifolii* Ashm.

of this material are given on page 17. Pay particular attention to the undersides of the leaves as the aphids are found there chiefly. Spraying with nicotine sulphate at the rate of $\frac{3}{8}$ of a pint to 40 gallons of water, to which is added 2 pounds of laundry soap, will give fair control but is not as satisfactory as dusting. A second or third application at intervals of a week to 10 days may be necessary if the infestation is heavy.

The Four-Lined Plant Bug*

In New Brunswick, this insect is frequently a pest of importance in garden plots or small potato fields. The winter is passed in the egg stage, the eggs being commonly laid in weeds and other plants growing on the margins of fields. As a result, when hatching takes place in the spring, potatoes growing at the edge of a field are more heavily attacked than those situated in a more central position. This is particularly true in the early part of the season when most of the insects are wingless and migration of necessity slow. After wings are developed the plant bugs spread more evenly over the field and injury then becomes less noticeable. In feeding, the insects pierce the leaves and suck out the enclosed juices. A black spot develops at each puncture and when the infestation is severe, entire leaves turn black and the plants become stunted and unthrifty. The four-lined plant bug is a pest of economic importance only in Eastern Canada.**

Fig. 8.—The four-lined plant bug, enlarged and natural size (after Dustan).

CONTROL

Dusting with a 5 per cent nicotine dust has given the best control against this insect. The material should be applied when the injury first becomes

* *Poecilocapsus lineatus* Fab.

** Prepared from information supplied by Mr. R. P. Gorham of the Entomological Laboratory, Fredericton, N.B.

apparent, which will be while the majority of the bugs are still wingless. Concentrate on the margins of the field and arrange to apply the dust on a warm, calm day. Directions for the preparation of nicotine dusts will be found on page 17.

INSECTS ATTACKING THE STEM

The Potato Stem Borer*

Primarily a pest of the small, backyard, potato patch, this insect seldom, if ever, causes any damage in commercial potato fields. The borer, which when full grown is about $1\frac{3}{4}$ inches long, pinkish-white in colour and with a brown head, has the unfortunate habit of migrating from stem to stem, thereby greatly increasing its powers of destruction. Attacked plants quickly wilt and eventually die. The moth of the potato stem borer lays its eggs in late August on weeds and grasses growing in the vicinity of such favoured host plants as potato, corn, rhubarb, etc. These eggs hatch in June of the following year, when the young borers seek out some fleshy-stemmed weed or cultivated plant, entering near the ground and tunnelling up the stem. This insect is a pest of importance only in Eastern Canada.

FIG. 9.—Work of the potato stem borer (original. from photo by S. H. Payne).

* *Hydroecia micacea* Esp.

CONTROL

(1) Destroy all weeds during the latter part of August and September, when the moths are laying their eggs. This applies, not only to weeds growing in the garden, but also to those present in surrounding wasteland.

(2) Practise crop rotation, following susceptible crops by others less frequently attacked, such as turnips, cabbages, etc.

(3) Pull and destroy plants as soon as injury is noticed, since this prevents the insects from migrating from host to host and multiplying the amount of injury.

Cutworms

Although not looked upon as a serious pest of the potato, cutworms occasionally cause considerable injury in isolated fields. The damage is done chiefly in the early part of the season when the plants are coming up, the cutworms hiding in the soil at the base of the vines and nipping off the young shoots as they break through the ground. The black cutworm (*Agrotis ypsilon* Rott.) sometimes appears later in the season, when it attacks the partially grown plants. However, these insects are not a regularly recurring pest in potato fields and only in exceptional cases are potato growers forced to take special remedial measures.

FIG. 10.—Potato vine cut down by black cutworms (original, from photo by R. P. Gorham).

CONTROL

Should cutworms be present in sufficiently large numbers to threaten the crop, the use of poisoned bran bait as mentioned on page 18 is recommended. If the plants are small, the bait should be broadcast over the field at the rate of 20 pounds to the acre. In fields where the vines are larger and sufficient foliage has developed to catch and hold the bran, the bait should either be placed around each plant or scattered along the rows. As cutworms feed at night, the bait should be distributed in the late evening of a warm day. Do not put it out at any other time, since it will be dry and unpalatable before the insects come up at sundown to feed, and if the evening is cold delay the application until weather conditions are more suitable. Two or three applications, at intervals of three days, may be necessary to control the cutworms.

IDENTIFICATION KEY TO INSECTS AND SLUGS ATTACKING THE TUBERS

I. Tubers showing distinct holes or feeding scars due to the work of insects:—

(*a*) Tubers with small round holes which connect with tunnels running through the flesh. The tissue surrounding the tunnels is frequently discoloured and in severe infestations rotted areas are commonly found..... *Wireworms*

(*b*) Tubers with large, open shallow excavations on the surface, the exposed tissue showing the feeding scars of the insects which resemble the teeth marks of mice and in many cases become wholly or partially healed over. Margins of excavations more or less even and regular, seldom ragged. Discoloration and rotting of flesh rare..... *White Grubs*

(*c*) Tubers with smaller but deeper excavations, having the edges surrounding the entrance holes ragged. Large chambers are eaten into the flesh and frequently the skin persists even though the underlying tissue has been entirely removed. Slime usually present, with discoloration and rotting of tissue common in storage ..... *Slugs*

II. Tubers without visible feeding scars but with minute, brownish, corky areas on the skin. These may be flat, slightly sunken or actually produced into definite depressions or very small tunnels, running into the flesh. Occasionally these areas take the form of tiny pimples.....
Potato Flea Beetle (larvæ)

INSECTS ATTACKING THE TUBERS

Wireworms

As wireworms are found naturally in sod and grassland, potatoes planted on freshly reclaimed ground are frequently attacked by these insects. They enter by way of the skin and in feeding make numerous tunnels through the tubers. The tunnels are about $\frac{1}{8}$ of an inch in width and are usually surrounded by darkened tissue. If the tubers are heavily infested, the flesh breaks down and rotting quickly sets in, which renders the potato unfit for market purposes. Heavy, damp soils are usually more severely infested than sandy, well-drained land.

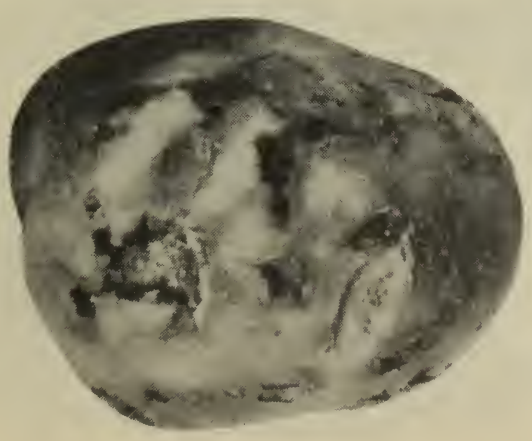

Fig. 11.—Potato damaged by wireworms (after Gibson and Twinn).

Wireworms are the young of click beetles which lay their eggs, preferably, in sod. The larvae, or wireworms, live in the ground throughout their life, feeding on the roots of grasses. They take at least three years to mature. These insects attack a wide range of wild and cultivated plants and are present in every province of Canada.

CONTROL

There is no specific control known for these insects, although growers may do much to lessen their destructiveness by proper farming methods, care in the selection of their land and in the choice of crops planted. Soil known to be infested with wireworms should be avoided and land free of this pest selected when choosing a spot in which to plant potatoes. Freshly broken sod should be carefully examined, since wireworms are frequently abundant in such situations. It is also well to remember that these insects prefer damp, poorly drained land. Encourage quick growth of plants through proper tillage and the liberal use of fertilizers. On land known to be infested, grow such crops as buckwheat, flax, alfalfa, clover, beans, peas, field peas, rape, turnips, mangels, sunflowers and squash. Then, when the soil is freed of these insects, susceptible crops, such as potatoes, corn and strawberries may be substituted. When grain is planted on land in which wireworms are present, seed somewhat more heavily than normal to provide for loss of some plants. Short rotations will be found helpful and should be practised on all infested farms.

White Grubs

White grubs are the young of June beetles and, like wireworms, are always more numerous in freshly broken land. The mature grubs are about 1½ inches in length, greyish-white, with brown head and legs. When at rest they usually lie curled in a half circle. Among other plants, these insects commonly attack the potato, eating out small, wide-spreading excavations which usually have regular and even margins. Definite chambers or holes are found only in the case of severe infestations. The jaw marks of the grubs are easily discerned in the eaten-over area and resemble the teeth scars made by mice. Rotting of the tissue

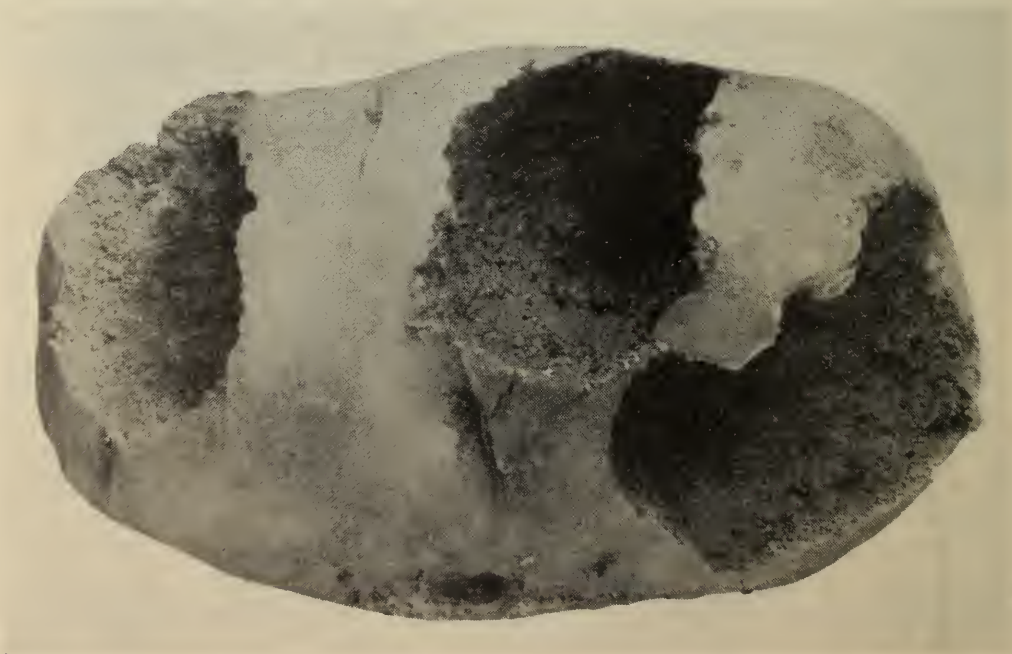

FIG. 12.—Potato damaged by white grubs (original, from photo by G. H. Hammond).

seldom follows the feeding of white grubs, although this is sometimes noticed when the tubers are lying in wet soil, but in most cases the exposed area heals over, forming a roughened scar.

The eggs of June beetles are laid preferably in sod and the resulting white grubs require three years in which to mature. During this time they live in the soil, where they feed on the roots of grasses and a wide range of other plants. The most destructive feeding takes place in the second year of their life. They are found in all the provinces of the Dominion but are of greatest economic importance in Quebec and Ontario.

CONTROL*

The greatest care should be used in selecting a field in which to plant potatoes in districts where white grubs are prevalent. Fields with a grub population of three or more per square yard should be avoided where possible and only these fields chosen which are known to have a small number of these insects present. Clay or heavy clay loam, soil standing in stubble or from which a hoed crop has just been removed are usually comparatively free of white grubs. Such soils should be fall-ploughed and thoroughly worked up in the spring before planting, as such practices assist in reducing the numbers of insects present.

Where it is not possible to select a piece of ground free from white grubs and where only heavily infested fields, such as old pasture or two-year-old meadow, are available, extra preparation of the soil becomes necessary. Plough in late September at a comparatively shallow depth, and follow with a thorough disking. In the spring, disk the ground four times before planting, or three times where a tractor is used. Such a cultural program should reduce the white grub population to a point where little injury to the tubers will result.

Sod land, which may be so situated as to become infested regularly with white grubs, can be protected from infestation. This can be brought about by scattering superfine sulphur, broadcast by hand or seed drill on the grass about May 24 at the rate of 300 pounds per acre. This practice should be of particular value where, for one reason or another, it is known a year in advance that a certain piece of sod, likely to be infested, will be desired for potatoes.

The treatment should be undertaken in the year of June beetle flight, and it will serve to protect the potatoes the following year when the grubs would be most destructive, by repelling the beetles when attempting to lay their eggs in the sod.

June beetles are only in flight in important numbers in most districts every third year. Their flight years are known for most parts of Canada so that if any difficulty is encountered in determining this in any locality, the information can be secured by applying to the Dominion Entomologist, Department of Agriculture, Ottawa.

Slugs

Potatoes growing on heavy land are sometimes attacked by slugs which not only feed on the foliage but also injure the tubers. When the tubers are attacked, the slugs eat their way through the skin and once inside clean out a cavity which, in some cases, may be almost as large as the potato itself. Frequently the skin remains intact, with the exception of the entrance hole, while in other cases it breaks away leaving a ragged, irregular opening fringed with fragments of skin. Traces of slime secreted by the slugs are usually found inside the tuber and, in storage particularly, rotting and blackening of the tissue frequently takes place.

While the vines remain green, the slugs confine their attack to stems and leaves of the plants, but as soon as the tops die down they turn their attention to the tubers, which are injured in the manner already described.

* Information on control supplied by G. H. Hammond, of the Entomological Branch, Ottawa.

CONTROL

There is no specific remedy for slugs when feeding on tubers, but if the vines are kept thoroughly sprayed or dusted with Bordeaux mixture throughout the summer little trouble will be experienced from this pest. Dusting infested plants with hydrated lime in the late evening will also kill many of the slugs. Since the slugs confine their attack to the foliage as long as it remains green, the shorter the time elapsing between the dying down of the tops and the removal of the tubers from the ground the better.

FIG. 13.—Potato damaged by garden slugs (after Gibson and Twinn).

INSECTICIDES IN COMMON USE AGAINST INSECTS ATTACKING THE POTATO

Stomach Poisons—For Biting Insects

ARSENATE OF LEAD.—This is the most commonly used insecticide to-day, due chiefly to the fact that it is absolutely safe to use on any foliage without fear of burning. Its chief disadvantages are that it kills insects rather slowly and is comparatively expensive. As a spray, it should be used at the rate of 1 to 1½ pounds to 40 gallons of water, or Bordeaux mixture, and in dust form is customarily diluted with 6 to 8 times its weight of hydrated lime, or other carrier.

ARSENATE OF LIME (calcium arsenate).—This arsenical is coming into more general use on account of its cheapness and rapid killing properties. It is more likely to cause foliage burning than arsenate of lead and for that reason, when used as a spray, a small amount of hydrated lime, about 2 pounds to 40 gallons, is usually added to neutralize the water soluble arsenic present. Arsenate of lime ¾ to 1 pound to 40 gallons of water is the usual dosage for this arsenical, or 1 part of poison to 10 parts of hydrated lime, when used as a dust.

PARIS GREEN.—Once a very popular poison, Paris green is being replaced by the above mentioned arsenicals due to its high cost, tendency to cause foliage injury, and to the fact that it is very difficult to hold in suspension when mixed with liquids. It is used in spray mixtures at the rate of ½ pound to 40 gallons of water, or Bordeaux mixture, and as a dust should be diluted with 15 to 20 parts of hydrated lime. When used as a spray with water, at least 2 pounds of hydrated lime should be added to each 40 gallons of solution.

Contact Poisons—For Sucking Insects

Nicotine Sulphate.—Nicotine sulphate (40 per cent) is the most commonly used contact insecticide for the control of sucking insects on field and garden crops. It is quite safe to use in either spray or dust form on the most delicate plants and can be safely combined with sprays containing insecticides and fungicides. It is usually used at the rate of $\frac{3}{8}$ of a pint to 40 gallons of water, to which has been added 2 pounds of laundry soap to increase its spreading and killing power.

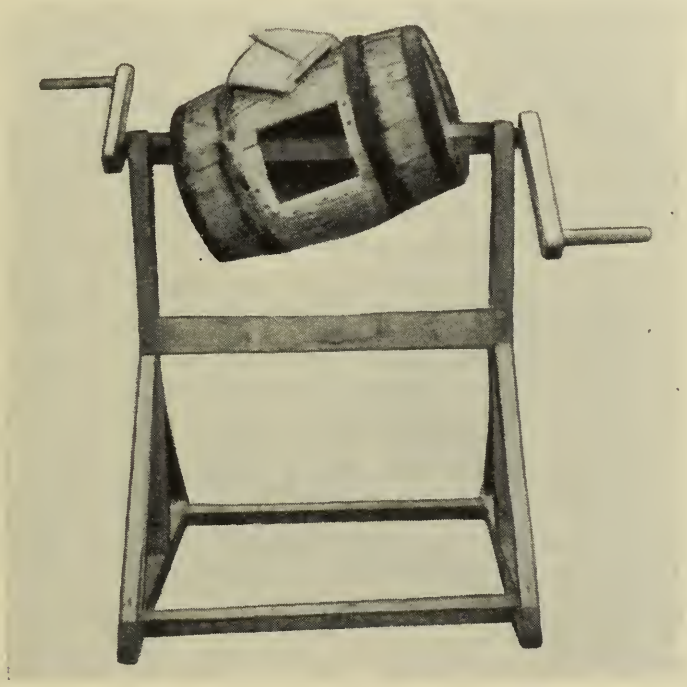

Fig. 14.—Dust mixer (after Dustan).

Nicotine Dusts.—Nicotine dusts, as used against sucking insects, are gaining in popularity on account of the comparative ease with which they can be applied and their greater effectiveness as compared with liquid applications. Nicotine dusts are made by mixing nicotine sulphate with hydrated lime, the strength of the dust, of course, being dependent upon the amount of the insecticide added. The most generally used dust is composed of 5 pounds of nicotine sulphate mixed with 95 pounds of hydrated lime, giving approximately a 2 per cent nicotine dust. However, when a stronger dust is required the amount of nicotine sulphate may be increased and the hydrated lime decreased proportionately. Nicotine dusts should be used as soon as mixed for best results, but if it is necessary to store them, they should be kept in air tight containers, since they quickly lose their strength if exposed to the air.

In preparing nicotine dusts, or dusts of other types mentioned later, the process can be speeded up and made much more effective if a barrel mixer is used. This consists of a barrel with an axle run through it, from end to end, which is slightly off centre. This axle has a handle at one end to facilitate turning and is mounted on a rough frame strong enough to support the barrel when partly filled with hydrated lime. A removable door is fitted in the side of the barrel by means of which the mixer is loaded. Several round stones about the size of a man's fist are placed inside. These have both a pulverizing and mixing effect on the dusts. The hydrated lime and nicotine are added, the door closed and the barrel turned slowly for 5 minutes, by which time a thorough mixing of the contents will have taken place. The dust is then removed and either used immediately or stored in tight containers.

Special Formulae

Bordeaux Mixture.—Bordeaux mixture, although primarily a fungicide, is also used as a control for many species of flea beetles and some leafhoppers. It is practically always used as the basic liquid when spraying for potato beetles, since it is the standard remedy for many important potato diseases. Bordeaux mixture is made by mixing copper sulphate (bluestone), hydrated lime and water together in the following proportions:

Copper sulphate (finely ground)	4 pounds
Hydrated lime	4 pounds
Water	40 gallons

The method is greatly simplified if finely ground copper sulphate and hydrated lime are used. After the spray tank has been filled with water, the engine is started and the correct amount of finely ground copper sulphate gradually added. With the agitator running, the fine powder will be thoroughly dissolved in 5 minutes. In the meantime the hydrated lime is placed in a large pail and slowly stirred with a stick while sufficient water is added to fill the container. After thorough mixing, the liquid is then gradually added to the now dissolved copper sulphate in the spray tank, while the engine and agitator continue to run. This proceeding is repeated 2 or 3 times until all the hydrated lime, with the exception of the insoluble foreign matter in the bottom of the pail, has been carried over into the spray machine. The Bordeaux mixture, which is pale blue in colour, is now ready to apply. Where small hand sprayers are used the method is exactly the same except that the agitation of the liquid in the sprayer will have to be done by means of a flat stick in the absence of an engine and mechanical agitator.

Bordeaux Dust.—In combating flea beetles or in treating potatoes for insect enemies, a Bordeaux dust may be used in place of the regular poisoned Bordeaux spray. Such dusts can be purchased from all commercial spray companies, ready mixed, or they may be prepared on the premises providing a good mixing machine is available. The following is the standard formula for Bordeaux dust:

Copper sulphate (dehydrated and ground very fine)	12 pounds
Hydrated lime	80 pounds
Arsenate of lime	8 pounds

The amounts of copper sulphate or arsenate of lime or both can be increased to suit the insect, but this must be compensated for by reducing the amount of hydrated lime to a corresponding extent so as to keep the total at 100 pounds.

Poisoned Bran Bait.—This bait is used chiefly for controlling cutworms and is composed of the following materials:

Bran	25 pounds
Paris green	$\frac{1}{2}$ pound
Molasses	1 quart
Water (about)	$2\frac{1}{2}$ gallons

The dry and wet ingredients should be mixed separately and then brought together in a tub or other large receptacle and the whole thoroughly stirred. When fully mixed the bait should be of the consistency of wet sawdust and should crumble and slip easily between the fingers. Do not have it too wet, since, if sloppy, it is impossible to spread it thinly and evenly over the ground.

Ottawa: Printed by J. O. Patenaude, I.S.O., Printer to the King's Most Excellent Majesty, 1936.